great, as is shown by the checking measurements made on both negatives between the points indicated by lines "A" and "B." The ratio of negative number 2 (the one made six months later than the other) to negative number 1, as shown by measurement "A" on both negatives is 1.338 ± 0.002. The ratio of negative 2 to negative 1, as shown by measurement "B" on both negatives, is 1.339 ± 0.002.

The following results were obtained by measurements of areas numbered 1, 2, and 3 on Plate I.

Results of Measurement of Albinistic Areas[8]

Area	*Measurement*	*Per cent of increase*	*Per cent of decrease*	*Per cent of error*
1	C		6.5	± .9
2	D	3.5		± .5
3	E	4.0		±1.0
1	F	1.0		±1.0

These results proclaim that the albinistic areas extended their borders, as shown by measurements "D" on area number 2, "E" on area number 3, and "F" on area number 1. The results also proclaim that the process of pigment metabolism was revived in area number 1, as shown by measurement "C," where the decrease of the size of the area was 6.5 per cent of its total height (vertical measurement of the body) with a possible error of ±0.9%.

[1] *Amer. Anthrop., New York*, N. S., **16**, 222–237 (1914).

[2] *Ibid.*, p. 234. [3] *Ibid.*, p. 235.

[4] *Ibid.*, p. 233. [5] *Ibid.*, p. 234.

[6] Number 32 of the Genealogical Chart, Fig. 74, p. 222 of *Op. Cit.*

[7] Mr. Wilcox is recognized as a most careful expert in the field of stellar photographic measurements.

[8] A detailed histological study of the skin of this person may be found in the article referred to in footnote number 1.

BANDED GLACIAL SLATES OF PERMO-CARBONIFEROUS AGE, SHOWING POSSIBLE SEASONAL VARIATIONS IN DEPOSITION

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Near Boston, on the peninsula of Squantum, facing Quincy Bay, is a formation of tillite of Permo-Carboniferous age, described in 1914.[1] Lying conformably on the tillite is a slate formation with a known thickness of about 800 feet.

The manner of transition from the tillite to the slate, together with other evidence, makes it certain that the slate was the result of deposition in waters from the melting of the glacier which formed the tillite. The first of the transition beds are conglomerates alternating with sandstones. Then come sandstones alternating with slates. At several places it is plain that the ice readvanced over these beds, ploughing them up and often dragging upward into the mass thus formed irregular lumps of the clay. As one goes upward in the banded slate it is seen that the layers of sandstone become thinner and thinner, then disappear entirely, and finally the alternating layers are shown only in slate of dark and light bands. The microscope reveals the fact that the dark layers are composed of much finer material than the light layers. The coarse layers all, without exception so far as observed, have very fine wavy lines of bedding which are cut off and uneven in places, while the fine layers are solid in appearance without these characteristic lines. The finest part of the fine layer is usually in contact with the coarse layer upward, and the change from fine to coarse is abrupt. The change from coarse to fine is more gradual upward, as a rule, and not abrupt. These layers or bands alternate with much regularity and at any given horizon their thicknesses also show regularity.[2] The microscope also shows that the slate with the finest banding also has the finest particles of sediment, although the mineralogical composition is the same as in the rest of the slate and in the tillite. This finest slate however, has more chlorite than the rest of the slate, giving it a light green color.

That the slate was derived from the tillite there can be no doubt. A microscopical examination by Prof. J. E. Wolff has shown the same mineralogical composition for both. The principal minerals present are as follows: quartz, feldspar, sericite, epidote, melaphyre, chlorite, limonite, quartzite and calcite. The size of the grains in the slate range from about 1/300 of an inch to as fine as about one 1/6000 of an inch. The shapes of the grains are angular as in ordinary glacial clay particles. As already stated the light bands usually have coarser as well as lighter material, but next to the thinnest sandstone layers coarser dark material is usually found, and this is just as it should be according to the laws of deposition. Thus it is seen that the banding in this slate is determined by the specific gravity of the material as well as by the strength of current.

Identical mineralogical composition alone, however, would not prove that the slate was derived from the tillite, but two beds of tillite in the slate itself, together with the facts of the banding, prove this origin. The first bed of tillite is about 50 feet above the main tillite formation

in well banded slate. The second tillite bed is about 150 feet from the main tillite. Each of these beds is about 5 feet thick. From the evidence presented by these tillite beds and several other beds of conglomerate in the slate, it is inferred that the final retreat of the glacier was slow and hesitating, marked by several advances after many years of retreat. It is known that the ice of the Wisconsin epoch of the Pleistocene period also began its retreat very slowly.

The cause of the disappearance of the sandstone layers and the gradual thinning of the bands can be explained by the retreat of the glacier and the consequent slackening of the currents, which would be strong enough to carry sand only in the neighborhood of the ice. The lower pebbly members of the transition beds show irregularities of deposition, especially in lenticular forms, due to the inconstant conditions of streams coming from a glacier. A regularity of alternation in deposition, however, becomes evident after the first 50 feet or so of the transition beds have been passed, where the layers indicate deeper and quieter water, and thus more uniformity in deposition. The thin individual layers now show through hundreds of feet such regularity in thickness and interval that a regularly recurring cause must be sought.

At the International Congress of Geologists at Stockholm in 1910, Gerard De Geer read a paper on the banding of the glacial clays in Sweden. He thinks, that the coarse band or layer gives a record of summer melting and deposition, and that the find band or layer gives the record of winter deposition of fine material, when the streams were slow and the fine material could easily settle on the bottom. With the co-operation of his students he was able to count the layers in the late glacial clays and then in the post-glacial deposits of the extinct Lake of Ragunda, which was drained in 1796, and gives 12,000 years as the time elapsed since the ice retreated from southern Scania to its present northerly position. The idea of measuring geological time in this manner came to De Geer in 1878. In this country B. K. Emerson advanced the same idea regarding the layers in the glacial clays of the Connecticut Valley in 1898.[3] Since that time several American geologists have published the theory. Among them may be mentioned A. P. Coleman, Frank B. Taylor, and Charles P. Berkey. As far as I can learn, however, De Geer is the first to conceive this geological time recorder, and also the first to convince the larger part of the geological world that these double bands in the glacial clays really mean years. No other explanation so far advanced, accounts for all the facts of the case. The facts observed in the slates at Squantum resemble so closely those described by De Geer and Emerson and the others, that it would seem as

if there must be a very strong probability of these being similar cases, in spite of the millions of years which separate the two glacial periods.

In speaking of the banding it is not possible at this writing to say anything about the formation of slate under the main tillite. The banding in this slate appears to be somewhat different from the banding in the slate under discussion, but there has not yet been time to study it. It should show points of interest in regard to the climate responsible for the glacial advance, while the slate above the tillite should show the conditions responsible for the retreat.

Evidence of seasons during Permian times has come from New South Wales, Australia, in the discovery of well marked annual rings of growth in trees of Permian Age.[4] From Brazil similar evidence was obtained in tree trunks of the same age, and perhaps in the Triassic period which followed.[5] Such findings, together with what now appears to be good evidence of seasonal changes at the locality which is now known as Boston, would make it appear that all these localities were in a temperate zone during Permian times as now. Furthermore, the close similarity between the layers in the Pleistocene glacial clays and the layers in the slate at Squantum would make it appear that the temperatures at the close of the Pleistocene and Permian were very similar.

Not all slates which exhibit banding are of glacial origin, but a close study of the slate at Squantum should give certain definite criteria for the determination of glacial slates at other localities, and thus reveal facts hitherto unknown concerning the past climate of the earth. As glacial till is usually a land deposit and subject to rapid erosion, it is not likely to be preserved as tillite unless submerged beneath a body of water relatively soon after deposition. This is not true of a glacial slate, for slate originates in water and is thus very much more likely to be preserved than tillite. Hence, it follows that the discoveries of glacial slates should be more numerous than discoveries of tillites, and such discoveries may turn out to be as good evidences of glaciation as the tillites themselves. In this new way it may be possible to obtain very much more knowledge of past geological climates than we could ever obtain by the search for tillites alone.

[1] R. W. Sayles, The Squantum tillite, *Bull. Mus. Comp. Zool., Harvard Univ.*, **46**, No. 2, 141–175 (1914).

[2] Charles P. Berkey, Laminated Interglacial Clays of Grantsburg, Wisconsin, *The Journal of Geology*, **13**, No. 1, 36–37. January-February, 1905.

[3] B. K. Emerson, The Geology of New Hampshire County, *U. S. Geol. Surv. Monogr.*, **29**, 706 (1898).

[4] Shirley and Arber, *Queensland, New South Wales, Bull. Geol. Surv.*, No. 7, 14 (1898).

[5] I. C. White, Relatorio final apresentado A S. Ex. o Sr. Dr. Lauro Severiano Müller, Comissão de estudias das minas de Carvão de Pedra de Brazil, Rio de Janeiro, 1908. (Printed in Portuguese and English.)